

## Advanced Computer Networks

### Take-Home Exam October 15, 2020

Name (Do NOT write your student ID number!): David Kirby

1. Make sure you have all 6 questions (100 points total).
2. Closed book, one sheet, two sides of notes allowed, no access to the Internet.
3. No copying, collaboration, or discussing the exam.
4. Either write by hand and scan – or type up your answers. Submit to UNM Learn.
5. Exam Duration: 24 hours (due by 2PM on Friday October 16, 2020).

1.(20) \_\_\_\_\_

2.(20) \_\_\_\_\_

3.(15) \_\_\_\_\_

4.(15) \_\_\_\_\_

5.(15) \_\_\_\_\_

6.(15) \_\_\_\_\_

Total (100): \_\_\_\_\_

1. (20%) The Chief Information Officer at UNM wants to install a new class live-streaming system on campus for the students to attend classes remotely on their laptops. As an excellent communications engineer, you are asked to propose a network architecture for this streaming system. Would you propose a circuit-switched, a packet-switched or a virtual circuit-switched solution? Summarize the pros and cons of each solution, and why you pick the one you propose. Show your work and use *engineering* arguments, e.g., cost, quality of service.

Circuit switching involves a dedicated channel where hosts are given full access to the entire channel for the entire transmission. This can have the benefit of less congestion, but if there is no data to be transmitted, the link is wasted (a negative impact to the overall cost of the network). Circuit switching also has the limitation of only allowing a certain number of hosts transmit at a time as each host must reserve a channel and the bandwidth is split between these channels. This is great in scenarios where a limited number of people are sending massive amounts of data, such as Facebook's local area network, but a bad implementation for this live-streaming system. Packet

switching is more on-demand, hosts do not need to reserve a channel, they instead break the transmissions into packets that are transmitted in a sequenced order over a shared channel. This, however, can create queuing delays (first-in, first-out), and as a result quality of service and quality of experience suffers, especially in our scenario where multiple students would be trying to access the network at once. In our particular scenario, I would suggest the third option, a virtual circuit-switched network such as MPLS. This technique would combine the advantages of both circuit and packet-switched networks. MPLS allows for packet-switching to break the transmission up (instead using fixed-length labels), but also utilizes the dedicated channel. All students could use transmit and receive, while maintaining a high quality of service.

2. (20%) Amy and John are part of a wireless local area network in a mountainous area of New Mexico. They live in the same municipality but at some distance apart, and a large hill is obstructing their ability to receive each other's signal directly. However, their WLAN still operates in infrastructure mode, via a centrally located base station/access point, which they both can "hear". Describe TWO different architectures/approaches that this WLAN could be based on. For each of the two architectures, sketch the main principles they would be based on, and how the "hidden terminal" problem would be overcome. Explain your answer, including arguments about efficiency, throughput, and cost.

The WLAN could be on the 802.11 architecture or could be on a cellular network architecture. Either way, infrastructure mode means that a main base station is in charge of assigning IPs, determining the locations of the hosts, and coordinating paths. One way to overcome the hidden terminal problem within the 802.11 architecture is by using request to send (RTS) and clear to send (CTS) control frames. If Amy or John want to transmit, they first send the RTS to the base station, which then transmits a CTS to all hosts, advising the others not to transmit. Even though these are small packets, the use of control frames increases the overhead on all transmissions.

3. (15%) Alice's laptop uses a standard TCP stack implemented in hardware that cannot be reprogrammed or altered by the user. Alice needs to use her laptop to access the Web over a WAN while commuting on a train each day. Which mobility solution would you select between "split connection TCP" and "TCP aware wireless link" (e.g., "snoop TCP")? Explain your answer, show your work.

Even though split connection TCP allows for faster recovery due to shorter round-trip times on the wireless link, something that would be very beneficial on a moving train, snoop TCP allows for better retransmission of lost packets. Also, snoop TCP preserves end-to-end TCP semantics and buffers data allowing for local recovery. Since the train will be moving and therefore quickly changing base stations, I would select snoop TCP.

4. (15%) What are the most important differences between 3G and 4G cellular systems? Be concise but also explain your answer carefully.

The biggest differences between 3G and 4G technologies are that 4G has one unique unified packet network (all IP core) and there is no separation between the voice and data portions. In 3G, after the radio component, there are splits between the public telephone network and the public internet components. This has been consolidated into one network on 4G as even landline phones are most likely sent over the internet as well.

5. (15%) Suppose that the great city of Albuquerque decides to become the smartest city in the USA by implementing ubiquitous high-speed wireless access (at least 20Mbps) accessible everywhere in the city: by people connecting to the Internet; by smart vehicles coordinating their routes; by a smart energy grid coordinating renewable energy flow and storage; and by smart public safety and crowd security systems. Would you recommend using Wi-Fi WLANs (e.g., from lamp posts in the street) or cellular 4G LTE? Justify your arguments carefully using reasonable assumptions, economic aspects, and other qualitative and quantitative factors.

I would recommend using cellular 4G LTE for a variety of reasons, the first of which being cost. Most of the infrastructure is already in place for 4G LTE across Albuquerque, while the cost to wire Wi-Fi WLANs would be tremendous. Even though we are talking about wireless LANs, there would still be need for power and potentially hundreds of miles of Ethernet; copper is expensive. The next concern would be mobility and hand-off – cellular has advanced this technology more than even the best mesh networks. Finally, our specifications only call for 20 Mbps connection, easily handled by today's 4G networks.

6. (15%) Suppose you are the Chief Engineer for Apple's iPhone 13. One of your talented Computer Engineers, a UNM graduate, comes to you with a bright idea: in the place of making the phone out of *open, standard, layer-based* hardware and software, instead work on a new super-optimized but "closed" architecture, with cross-layer shortcuts, and violations of layering and standards, that could save at least \$100 per device manufactured to order at the Apple factory, and also \$1 operating costs for each day that the phone is operated. What would you do? And what would be the rational basis for your response? State your assumptions and be precise and quantitative.

Saving \$100 per device would equate to very little if no one bought the device because it would not work with any other network. The open, standards-based approach is there to maintain interoperability; while layering is meant to preserve redundancy in the stack. If we built a cross-layered network and one layer has issues, it could affect the entire stack, leading to a network outage; and, since our network was not compatible with other networks, there would be no fallback for our devices to operate on. Forgoing an open, standard, layer-based network would also mean that as new advances are made in software or hardware, we would have to change our entire network to adapt and maintain, creating more of a monetary and quality of experience nightmare. I'm old enough to remember the GSM/CDMA debates in the early 2000s. It was a hassle trying to determine if the phone I bought at AT&T would work on Verizon's network. I would advise my talented computer engineer to try to incorporate their "super-optimized" technology into the open standards that exist.